DOCUMENT RESUME

ED 295 802 SE 049 176

AUTHOR Marshall, Sandra P.
TITLE Schema Knowledge for Solving Arithmetic Story Problems: Some Affective Components.
INSTITUTION San Diego State Univ., CA. Center for Research in Mathematics and Science Education.
SPONS AGENCY Office of Naval Research, Arlington, Va.
REPORT NO CRMSE-88-01
PUB DATE May 88
CONTRACT N-00014-K-85-0661
NOTE 25p.
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Affective Behavior; Affective Measures; *Cognitive Structures; Elementary Education; *Elementary School Mathematics; Mathematics Curriculum; Mathematics Education; Mathematics Instruction; *Problem Solving; *Schemata (Cognition)
IDENTIFIERS *Mathematics Education Research

ABSTRACT

This report discusses the role of affect in cognitive processing. The importance of affect in processing mathematical information is described in the context of solving arithmetic story problems. Some ideas are offered about the way affective responses to mathematical problem solving situations influence the development, maintenance, and retrieval of information stored in human memory. A model of human memory based on schema knowledge structures is outlined. A way that affective information may be stored within a schema is suggested. The report concludes with a discussion of some affective responses to mathematics evidenced by students' comments as they worked with story problems. (PK)

**********
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
**********

SE

ED295802

SDSU

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☒ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy

# SCHEMA KNOWLEDGE FOR SOLVING ARITHMETIC STORY PROBLEMS: SOME AFFECTIVE COMPONENTS

Sandra P. Marshall

May 1988

## Center for Research in Mathematics and Science Education

**College of Sciences**
**San Diego State University**
**San Diego, CA 92182-0413**

This research is supported by the Office of Naval Research, Cognitive Sciences Programs, Contract No. N-00014-K-85-0661.

Reproduction in whole or part is permitted for any purposes of the United States Government.

Approved for public release; distribution unlimited.



BEST COPY AVAILABLE

SE 049 174

SECURITY CLASSIFICATION OF THIS PAGE

## REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

| | |
|---|---|
| 1a. REPORT SECURITY CLASSIFICATION<br>Unclassified | 1b. RESTRICTIVE MARKINGS |
| 2a. SECURITY CLASSIFICATION AUTHORITY | 3. DISTRIBUTION/AVAILABILITY OF REPORT<br>Approved for public release; distribution unlimited |
| 2b. DECLASSIFICATION/DOWNGRADING SCHEDULE | |
| 4. PERFORMING ORGANIZATION REPORT NUMBER(S)<br>CRMSE Report No. 88-01 | 5. MONITORING ORGANIZATION REPORT NUMBER(S) |
| 6a. NAME OF PERFORMING ORGANIZATION<br>CRMSE, San Diego State University<br>6b. OFFICE SYMBOL (If applicable) | 7a. NAME OF MONITORING ORGANIZATION<br>Cognitive Sciences Program<br>Office of Naval Research |
| 6c. ADDRESS (City, State, and ZIP Code)<br>Psychology Department/CRMSE<br>San Diego, CA 92182 | 7b. ADDRESS (City, State, and ZIP Code)<br>800 N. Quincy Street (Code 1142PT)<br>Arlington, VA 22217-5000 |
| 8a. NAME OF FUNDING/SPONSORING ORGANIZATION<br>Office of Naval Research<br>8b. OFFICE SYMBOL (If applicable) | 9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER<br>N00014-K-85-0661 |
| 8c. ADDRESS (City, State, and ZIP Code)<br>800 N. Quincy Street<br>Arlington, VA 22217-5000 | 10. SOURCE OF FUNDING NUMBERS<br>PROGRAM ELEMENT NO. 61153N; PROJECT NO. RR04206; TASK NO. RR04206-0C; WORK UNIT ACCESSION NO. NR 442c-010 |
| 11. TITLE (Include Security Classification)<br>Schema Knowledge for Solving Arithmetic Story Problems: Some Affective Components | |
| 12. PERSONAL AUTHOR(S)<br>Sandra P. Marshall | |
| 13a. TYPE OF REPORT<br>Technical<br>13b. TIME COVERED FROM 9-1-86 TO 9-1-87 | 14. DATE OF REPORT (Year, Month, Day)<br>5/20/88<br>15. PAGE COUNT<br>12 |
| 16. SUPPLEMENTARY NOTATION | |
| 17. COSATI CODES<br>FIELD / GROUP / SUB-GROUP | 18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)<br>Problem solving, cognitive processes, mathematics instruction, knowledge representation |

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

In this paper I discuss the role of affect in processing information about arithmetic story problems. I outline a model of human memory based upon schema knowledge structures, and I suggest how affective information may be stored within a schema. Comments made by students during interviews provide examples of different affective responses.

| | |
|---|---|
| 20. DISTRIBUTION/AVAILABILITY OF ABSTRACT<br>☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS | 21. ABSTRACT SECURITY CLASSIFICATION |
| 22a. NAME OF RESPONSIBLE INDIVIDUAL<br>Susan Chipman | 22b. TELEPHONE (Include Area Code)<br>(202) 696-4318<br>22c. OFFICE SYMBOL |

DD Form 1473, JUN 86 *Previous editions are obsolete.* SECURITY CLASSIFICATION OF THIS PAGE

# SCHEMA KNOWLEDGE FOR SOLVING ARITHMETIC STORY PROBLEMS: SOME AFFECTIVE COMPONENTS

Sandra P. Marshall
Department of Psychology
Center for Research in Mathematics and Science Education
San Diego State University
San Diego, California 92182

This work is supported by the Office of Naval Research, Cognitive Sciences Program, Contract No. N00014-85-K-0661. Reproduction in whole or part is permitted for any purpose of the United States Government. Approved for public release; distribution unlimited.

A version of this paper to appear as "Affect in Schema Knowledge: Source and Impact" in McLeod, D. B., & Adams, V. M. (Eds.), Affect and mathematical problem solving: A new perspective. Springer-Verlag.

# SCHEMA KNOWLEDGE FOR SOLVING ARITHMETIC STORY PROBLEMS: SOME AFFECTIVE COMPONENTS

Sandra P. Marshall
Department of Psychology
Center for Research in Mathematics and Science Education
San Diego State University
San Diego, California 92182

In this report I discuss the role of affect in cognitive processing. The importance of affect in processing mathematical information is described in the context of solving arithmetic story problems. More specifically, I offer some ideas about the way affective responses to mathematical problem-solving situations influence the development, maintenance, and retrieval of information stored in human memory. I outline a model of human memory based upon schema knowledge structures and I suggest how affective information may be stored within a schema. The report concludes with a discussion of some affective responses to mathematics evidenced by students' comments as they worked with story problems.

The topic is introduced with descriptions of two affective responses to solving arithmetic story problems. Although the situations are hypothetical, they correspond in general to those that in practice elicit the two responses. The responses themselves are not hypothetical. I have observed them repeatedly in my own research and in anecdotes related to me by colleagues. The situations are useful in my later consideration of how affect influences cognitive processing and how it may be stored in human memory.

## The Emotional Response

Imagine the situation in which a child is learning to solve arithmetic story problems. The child is presented with a problem and is asked to find the solution. The story problem is a typical textbook one having key words such as "altogether" or "have left". The child guesses that addition would be appropriate and carries out the addition algorithm successfully.

Suppose that the solution is correct and suppose that the child then attempts to solve another problem but does not get the correct answer. There are many ways for error to occur. Some of the words may have been misread or key words imagined to be present when they were not. An incorrect association between a key word and an arithmetic operation could have been drawn. The operation may have been correctly identified but be confused in the child's understanding with another operation. The operation may have been correctly chosen but have a bug in the algorithmic application. Finally, there may simply have been a careless slip or transcription error in the writing down of some of the numbers.

The child probably will not recognize what is wrong with the solution and will not understand why the answer to the previous problem was correct and the answer to the current one incorrect. The child believes that the same thing was done in both situations with the result that the child's actions were correct on one occasion and incorrect on another. What will the child's response be?

While a single error may not cause the child to experience emotion about problem solving, repeated episodes of this type may lead to a sense of frustration, a distrust of the child's own skills, or a general feeling of unease. The immediate feedback the child receives from parents, teachers, and peers may cause additional emotional reactions such as embarrassment or shame. These emotions, like other features of the situation, will influence the child's performance now and will also be encoded in memory as part of the experience of problem solving.

## The Attitudinal Response

Picture this same child several years later in situations in which the child is required to solve story problems. Now, whenever the child is presented with a problem, the initial response is "I don't like story problems." Mere recognition of the situation is sufficient to trigger the affective response. The child does not need to be engaged in solving the problem.

This is an attitudinal response. It differs from an emotional one in at least two ways. First, the attitudinal response comes from the activation of previously stored affective memories. The emotional response comes about as the reaction to emotion that arises during the situation. Second, the attitudinal response is typically dispassionate (i.e., cold rather than hot). The emotional response may be an intense feeling accompanied in extreme cases by nausea, increased heart beat, or shaking hands. The attitudinal response, in contrast, does not usually activate observable physiological reactions. In this sense it is cold. It may still have an impact upon the child's willingness to engage in problem solving and may be itself sufficiently strong to block the child's attempts to search memory for appropriate techniques to solve the problem.

These are not the only two affective responses that can be observed in mathematics situations, but they are the most common. In the remainder of this report, I describe a model of cognition that accounts for how these responses are encoded in memory with other situational features and how their retrieval may influence the retrieval and activation of many aspects of problem solving.

## THE ORGANIZATION OF HUMAN MEMORY INTO SCHEMA KNOWLEDGE STRUCTURES

Human memory has been described under several organizing principles. For example, Tulving (1972) talks about episodic versus semantic knowledge. Anderson (1983) focuses on procedural versus declarative memories. Hinton, McClelland and Rumelhart (1986) describe microfeatures in models of parallel distributed processing. What is common in these hypothesized knowledge structures is the general organization of long-term memory into networks. Individual pieces of knowledge are viewed as nodes in the networks. These nodes may be linked together or may exist as isolates. Retrieval of information from memory depends upon where the information resides within the network. Information that has many links to other nodes usually has a higher probability of retrieval than knowledge that is unlinked because there are more paths through the linked network. Access to an isolate node demands a retrieval path directly to the node itself. Access to a highly-connected node may be indirect, beginning with a node far removed from the target but connected to it over one or more paths through the network. In the latter case, access could begin with any of the connected nodes rather than only with the target node.

The network concept of human memory helps us to understand some of the research findings in studies of expert and novice performance. Experts appear to have rich, highly interconnected networks. Novices are more likely to have fragmented, partially linked networks, possibly with inappropriate links between nodes. Psychological studies of retrieval and forgetting also support the network structure of memory. Comparisons of recognition and recall demonstrate that it is easier to retrieve knowledge from memory given cues that allow multiple paths through memory nodes than from cues that lead only to a single isolated node.

During the process of retrieval, how are some nodes selected and others ignored? Psychologists suggest that the links between nodes carry measured impulses, either positive or negative. Thus, the activation of one node (perhaps through direct access) causes the activation of other surrounding nodes that are linked to the target. At the same time, this activation may also inhibit another set of nodes through negative connections.

It is a reasonable supposition that links between nodes vary in intensity. The degree to which activation spreads among nodes will be influenced by the strength of the associations that connect the nodes. Consequently, some nodes will receive a high degree of stimulation while others receive a lesser amount.

Through learning -- both intentional and incidental-- individual nodes are added to long-term memory and groups of them become connected. I hypothesize here and elsewhere that the primary mechanism under which these connections are made and by which meaningful learning occurs is the schema. A schema is a knowledge structure that allows the individual to recognize aspects of his or her environment and to operate on them, either abstractly or concretely. That is, the schema governs the individual's interactions with the environment. Schemas are especially important in problem-solving situations because these situations demand responses of the individual, and schemas are the means by which these responses are constructed by the individual.

What constitutes a schema? In earlier research, I have developed a model of the schema built upon four basic components (c.f., Marshall, Pribe, & Smith, 1987). First, there is a generic representation of the situation to which the schema applies. This component contains all of the facts, descriptors, and embellishments about the general instance in which the schema will be used. Related to this is the second component that consists of the restrictions and conditions that must be met if the schema is actually to be instantiated. Thus, the first component has the general description and the second has the tests of goodness of fit of the description to the current situation. The third component contains planning mechanisms related to implementing the schema. Within this component are particular goals and sub-goals that may be expected as well as general goal-forming procedures. Finally, the fourth component has the actions and procedures that govern the actual implementation of the schema.

In a fully developed schema these four components would each be subsets of interconnected nodes, with links running between components as well as within them. Initial access to the schema could be through any of the four subsets, resulting in activation of the entire set of nodes that define the schema. Thus, faced with a problem, an individual might first recognize the general form of the problem (component one), might notice initially the presence or absence of a particular constraint (component two), might focus upon the obvious goals and secondary goals that must be achieved prior to solution (component three), or might identify particular actions that would be appropriate to the situation (component four). Each of these would activate the others. The depth to which any component might be activated and accessed by the individual depends upon the complexity of the problem. Trivial problems require little cognitive processing. Difficult ones might involve access to many different schemas.

This conception of memory organization has been applied mainly to the acquisition and storage of knowledge as it relates to cognitive skills. In particular I have developed the model with respect to the knowledge required to solve arithmetic story problems (Marshall, Pribe, & Smith, 1987; Marshall, 1987). It is my purpose here to extend the model to include affective components of problem solving as well.

## AFFECTIVE LINKS IN THE SCHEMA MODEL

There are at least two means by which affect can enter schema knowledge. The affective features of the situation may be learned at the same time that other features of the schema are encoded. Alternatively, the affective response to the situation may be developed after the schema is fully formed and be, in effect, a secondary encoding related to the pre-existing schema. I will consider each of these separately.

### Simultaneous Encoding

Return to the first situation described above. While solving the first story problem, the child encodes in memory certain aspects of the situation. Because the child is learning to solve these problems, he or she does not already have a schema that will guide and structure a response to the situation. The process of making the decision to add and of carrying out the algorithm creates weak bonds among features of the problem situation, such as the key word "altogether", the process of making the choice of operation, and the action of carrying out the computation. Further, if the child's answer is correct, another node may be linked to the others indicating that tasks such as these are not difficult or are even pleasurable.

As the child encounters the second problem and makes an error, the link to the positive affect node will be weakened and a competing link will be formed with a negative affect node. Repeated failures will strengthen this link. Repeated successes weaken it and strengthen the positive one.

For a single problem, the child is unlikely to encode an affect node unless the situation is exceptionally threatening or rewarding. However, if the child continues to attempt to solve problems and continues to err, a node of negative affect will be encoded, strengthened, and linked to the problem-solving process. With repeated failures and frustrations, the affect node becomes stronger and its links to other features of the problem situation also become stronger. Eventually, one predicts that the presentation of a story problem will evoke a strong negative reaction from the child because the schema itself has been created in the presense of the affective response. In this case, affect is a feature of the situation and has been encoded along with other features.

Encoded in this way, the affect node is a multi-connected one with links to many other nodes in the schema. It is not an isolate that becomes activated alone. Just as with any other feature of the problem-solving situation, it will have stronger links to some nodes and weaker ones to others.

Where in the schema structure can affect nodes reside? That is, to which other nodes will affect nodes be strongly connected? Since errors of solution can be the result of incomplete or inappropriate elements in any of the four components of schema knowledge, it seems reasonable that negative (and positive) affect nodes can also be found in any of the four components. For example, an individual may have developed an affective response to a particular type of algebra problem that was a source of difficulty in the past. Consequently, when faced with a problem that begins "Two trains leave New York at the same time ...", he or she immediately experiences a negative response. In this case, the form of the problem is part of the schema knowledge (the first component of general description) and the affect is linked directly to the encoding of motion problems. An equally difficult mixture problem ("Seth has 10 more quarters than dimes ...") may evoke no affect or even positive affect, depending upon the emotional aspects of previous problem-solving experiences.

Posterior Encoding

There appear to be cases in which individuals develop schema knowledge structures with little or no apparent affect links. One can imagine a competent mathematics student entering a mathematics contest and experiencing a negative reaction for the first time while attempting to solve a particular problem. This student will probably already have a highly developed set of schemas and be able to access them readily. Depending upon the strengh of the affective reaction to the current experience, the student may encode the negative affect in such a way that it links to the schema(s) as a whole. Thus, if the contest involves calculus problems, the student may develop an immediate dislike of all problems requiring integration. In this case, the affect node becomes connected to all parts of the schema. The schema nodes are already tightly linked and have probably achieved a level of activation that makes the instantiation of the schema appear automatic. When an affect node attaches to an existing schema, it connects equally to all parts of the schema. This bonding is in contrast to simultaneous encodings in which affect nodes are linked more strongly to the elements with which they were first associated.

It is reasonable that simultaneous and posterior encodings will lead to different outcomes for individuals solving mathematics problems. Part of the difference comes in the specific versus diffuse connections between affect nodes and other nodes. When the affect encoding takes place at the same time that other features are encoded, the links are specific, leading from one node directly to another. They are also relatively localized, extending primarily to nodes within one subcomponent of the schema. In contrast, posterior encodings lead to links that are more diffuse because they are formed between the affect nodes and the schema itself.

One can surmise that it may be easier to change affective responses that were coded simultaneously than to alter posterior encodings. Since the simultaneous encodings result from specific instances, they have links to identifiable parts of the schema. If positive experiences can be created that link to these same parts, a tension can be generated between the positive and negative responses to the same features of the problem. It is nice to think that many positive experiences could sufficiently weaken the older negative bond to the degree that the positive links would be dominant. Whether or not this is true is an empirical question and is an important research issue yet to be addressed.

## EXAMPLES OF AFFECTIVE RESPONSES

There is some evidence consistent with the hypothesis that affect is coded as described above. This evidence comes from students' responses to open-ended questions about their problem-solving strategies and techniques.

### Data Description

Several years ago I undertook a research project that necessitated interviews of approximately 100 sixth-grade children enrolled in two elementary schools. Each child was interviewed for approximately one hour. During this time, the child responded to a traditional paper-and-pencil test of ten story problems and then discussed with the interviewer an additional 10 story problems. Most of the problems required two computations for solution and involved whole numbers or fractions.

The children were asked to solve the problems on the paper-and-pencil test. They were not asked to find solutions to the problems discussed in the interview. Instead, they were asked to describe how they might solve these problems, to talk about making a plan to solve them, and to point out important information in them. A discussion of the students' success in solving the problems and an examination of the strategies they used are given

elsewhere (Marshall, 1982). Here, I describe their manifest affective reactions to the interview.

The interviewer in this study was a soft-spoken young woman who relates well to children and interacts easily with them. She had worked with handicapped children and had also taught children with reading difficulties. It is evident from the audiotapes that she encouraged the children to verbalize their feelings as they solved the problems, although this verbalization was not an explicit objective of the original study.

## Affective Responses

The children's responses during the interview were recorded in brief notes by the interviewer and were also audiotaped. The purpose of the original study was to examine the strategies used by sixth graders as they solved a set of problems. Of interest here is that most of the children volunteered affective information as well as details about their strategies (or lack thereof). The affective statements were interspersed throughout the interviews.

Positive responses. Most of the affective comments were negative, but there were some notable exceptions. One child made the following response, as she checked her answer to a problem requiring the use of fractions: "I was right ... it adds up ... this is fun!" . She went on to comment later on the relation between addition and multiplication and was very pleased to recognize and describe the connection. She enjoyed showing the interviewer how multiple additions would yield the same answer as a multiplication computation. These responses suggest that the affect is linked to the procedures she used in solving the problems. This is an example of affect within the fourth component of schema knowledge.

Other positive responses were less specific. One of the students responded very confidently "It's easy" to one problem and "This one's a little harder" to the next one. He later commented with enthusiasm to a third problem: "I don't know how to solve it but I know the answer." (He did have the correct answer.)

There are two different affective responses here. The first statements are examples of values given to the problems based only upon reading the items. The affect nodes here are attitudinal and are probably connected to the features encoded in the general descriptive component of the schema. The affective response was made prior to any attempt to solve the problem. The third response by the student is positive. Even though he was unable to describe the procedures, he was certain that he understood the problem and had the answer, and he was correct. How this affective information is encoded is unclear. The student's

understanding of the problem and his solution may result from a highly automated and fully activated schema. Individuals are frequently unable to access specific features of automatic responses. The student's confidence implies that he understands the situation despite his inability to describe his solution strategy.

Negative responses. As might be expected from other studies of affect in mathematics, many of the students' responses were negative. Most of the responses could be classified as cold, reflecting attitudes about the situation. Nonetheless, there were some instances of obvious "hot" affective responses. For example:

Interviewer: Any idea about how to solve this one?

Child: I think. I think that she ... she counted 7 heads and 24 legs ... um ... I had something ... I think she counted ... okay ... 7 heads and twenty ... (pause, trails off) ... okay ... I think she ... okay ... she counted 7 heads and I think there were 14 um ... parakeets and ... (pause) ... 10 hampsters or whatever.

Interviewer: Okay, how did you get that?

Child: I went ... she had 7 heads so ... oh, my heart is beating so fast ... (trails off)

Interviewer: Are you scared?

Child: Yeah.

Interviewer: Why? This is okay. Just relax. It's all right. Okay? You're doing a tremendous job. You are doing very well.

Following this exchange, the child continued to talk about the problem and her solution to it. However, after solving two more problems her hands began shaking. The interviewer ended the session and spent several more moments reassuring the child that she had performed well on the tasks.

The majority of the "hot" responses were less dramatic. Several students reacted to the situation with steadily rising voices. By the end of the interview, these students were giving inflections to all of their statements, indicating a lack of confidence in their responses.

The most frequent negative affect was demonstrated in statements reflecting either a dislike of the task ("I hate this") or a self judgment of the child's ability ("I'm no good at this"). Responses of both types are consistent with stored affect linked to various schema components.

Few affective reactions could be attributed to the first component of schema knowledge described above. That is, students did not seem to have reactions to the general situations described in the problems. I hypothesize that such reactions are more likely to arise in other mathematics situations such as algebra or calculus. At the sixth grade children do not recognize situation similarities and thus would have no strong grouping of nodes to reflect the general description of various situations (Marshall, 1987).

There was evidence of affective links to other components of schema knowledge, particularly to the planning component. For example, one student routinely ended her comments about solving each problem with negative statements including the following: "This is probably wrong," "That's probably wrong," "I'm doing terribly." Most of these comments seemed to refer to her choice of operation and were made after she described why she elected to use a particular arithmetic operation. She did not voice hesitations as she carried out the computations. Thus, it is likely that the negative affect for this child is linked to the third component (the planning and goal-setting component) rather than the procedural component through which the actions are actually carried out.

Other children also expressed negative affective about making operation choices. One child commented, "I'm good with fractions but not word problems with fractions." Presumably this means that the child feels confident when told what operation to execute but is hesitant about choosing the operation when it is not specified.

Some responses seemed to indicate the presence of affective links with the constraints found in the second component of schema knowledge (constraints and conditions for using the schema). Several students expressed the belief that "They're trying to trick you" without specifying who <u>they</u> might be. These students had difficulty understanding the problems. One said the following: "Oh, I hate these problems ... Why can't they just put numbers? ... I don't understand them ... I don't like these." Generally, statements such as these were followed by the student's pronouncement that he or she could not solve the problem and would like to move to a different problem. These responses appeared without any reference to planning or goal-setting considerations. That is, they attach to the second component of schema knowledge (the recognition of constraints that govern use of the schema).

<u>Summary</u>. The responses of these children provide evidence of both hot and cold -- emotional and attitudinal-- reactions. There were clear physiological indicators such as shaking hands, raised voices, and the self report ofincreased heart rate. There were also unemotional statements of dislike and inability.

Most of the affective responses were in accord with the model of schema acquisition and use outlined above. A tentative conclusion is that these responses support the simultaneous encoding of affect and problem features. There were some global responses to problem solving, but most of the children mentioned specific aspects that caused the distress.

Finally, it is encouraging that at least some of the students volunteered positive affective reactions. When students felt that they understood a problem and its solution, they spoke confidently and enthusiastically about solving it. For this group of students, positive affect appeared to be associated with their own self evaluations of understanding.

## REFERENCES


Anderson, J. R. (1983). The Architecture of Cognition. Cambridge, MA: Harvard University Press.

Hinton, G. E., McClelland, & Rumelhart, D. E. (1986). Distributed representations. In D. E. Rumelhart & J. L. McClelland (Eds.), Parallel Distributed Processing: Explorations in the Microstructure of Cognition, Volume 1. Cambridge, MA: The MIT Press.

Marshall, S.P. (1982). Sex Differences in Solving Story Problems: A Study of Strategies and Cognitive Processes. (Final Report, Grant NIE-G-80-0095). Washington, DC: National Institute of Education.

Marshall, S. P. (1987, April). Knowledge Representation and Errors Problem Solving: Identifying Misconceptions. Paper presented at the Annual Meeting of the American Educational Research Association, Washington, D.C.

Marshall, S. P., Pribe, C. A., & Smith, J. D. (1987). Schema Knowledge Structures for Representing and Understanding Arithmetic Story Problems. (Tech. Rep. Contract No. N00014-85-K-0661). Arlington, VA: Office of Naval Research.

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving and W. Donaldson (Eds.), Organization and Memory. New York: Academic Press.

Dr. Beth Adelson
Department of Computer Science
Tufts University
Medford, MA 02155

Air Force Human Resources Lab
AFHRL/MPD
Brooks, AFB, TX 78235

AFOSR, Life Sciences Directorate
Bolling Air Force Base
Washington, DC 20332

Dr. Robert Ahlers
Code N711
Human Factors Laboratory
Naval Training Systems Center
Orlando, FL 32813

Dr. John R. Anderson
Department of Psychology
Carnegie-Mellon University
Schenley Park
Pittsburgh, PA 15213

Dr. Nancy S. Anderson
Department of Psychology
University of Maryland
College Park, MD 20742

Technical Director, ARI
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Patricia Baggett
School of Education
610 E. University, Rm 1302D
University of Michigan
Ann Arbor, MI 48109-1259

Dr. Eva L. Baker
UCLA
Ctr for the Study of Evaluation
145 Moore Hall
University of California
Los Angeles, CA 90024

Dr. William M. Bart
University of Minnesota
Dept. of Educ. Psychology
330 Burton Hall
178 Pillsbury Dr., S.E.
Minneapolis, MN 55455

Dr. Lee Roy Beach
Dept. of Psychology (NI-25)
University of Washington
Seattle, WA 98195

Dr. Isaac Bejar
Mail Stop: 10-R
Educational Testing Service
Rosedale Road
Princeton, NJ 08541

Dr. John Black
Teachers College, Box 8
Columbia University
525 West 120th Street
New York, NY 10027

Dr. R. Darrell Bock
University of Chicago
NORC
6030 South Ellis
Chicago, IL 60637

Dr. Jeff Bonar
Learning R&D Center
University of Pittsburgh
Pittsburgh, PA 15260

Dr. J. C. Boudreaux
Ctr for Manufacturing Eng
National Bureau of Standards
Gaithersburg, MD 20899

Dr. Robert Breaux
Code 78
Naval Training Systems Ctr
Orlando, FL 32813-7100

Dr. John S. Brown
XEROX Palo Alto Research Ctr
3333 Coyote Road
Palo Alto, CA 94304

Dr. John T. Bruer
James S. McDonnell Foundation
Suite 1610
1034 South Brentwood Blvd.
St. Louis, MO 63117

Dr. Joanne Capper, Director
Ctr for Research into Practice
1718 Connecticut Ave., N.W.
Washington, DC 20009

Dr. Susan Carey
Dept of Cognitive & Neural Science
MIT
Cambridge, MA 02139

Dr. Pat Carpenter
Carnegie-Mellon University
Department of Psychology
Pittsburgh, PA 15213

Dr. John B. Carroll
409 Elliott Rd., North
Chapel Hill, NC 27514

CDR Robert Carter
Office of Chief of Naval Operations
OP-933D4
Washington, DC 20350-2000

Dr. Davida Charney
English Department
Penn State University
University Park, PA 16802

Dr. Michelene Chi
Learning R & D Center
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15260

Dr. William Clancey
Institute for Research on Learning
3333 Coyote Hill Road
Palo Alto, CA 94304

Asst Chief of Staff for Research
Development, Test, and Evaluation
Naval Education and
Training Command (N-5)
NAS Pensacola, FL 32508

Dr. Paul Cobb
Purdue University
Education Building
W. Lafayette, IN 47907

Dr. Allan M. Collins
Bolt Beranek & Newman, Inc.
10 Moulton Street
Cambridge, MA 02238

Dr. Stanley Collyer, Code 222
Office of Naval Technology
800 N. Quincy Street
Arlington, VA 22217-5000

Dr. Jere Confrey
Cornell University
Dept. of Education
Room 490 Roberts
Ithaca, NY 14853

Dr. William Crano
Department of Psychology
Texas A&M University
College Station, TX 77843

Dr. Cary Czichon
Intelligent Instructional System
Texas Instruments AI Lab
P.O. Box 660246
Dallas, TX 75266

Brian Dallman
Training Technology Branch
3400 TCHTW/TTGXC
Lowry AFB, CO 80230-5000

Dr. Robert B. Davis
Curriculum Laboratory (Education
University of Illinois
Urbana, IL 61801

Dr. Sharon Derry
Florida State University
Department of Psychology
Tallahassee, FL 32306

Dr. J. Stuart Donn
Faculty of Education
University of British Columbia
2125 Main Mall
Vancouver, BC CANADA V6T 1Z5

Defense Technical Information Ct
Cameron Station, Bldg 5
Alexandria, VA 22314
Attn: TC
(12 Copies)

Dr. Richard Duran
Graduate School of Education
University of California
Santa Barbara, CA 93106

Dr. Susan Embretson
University of Kansas
Psychology Department
426 Fraser
Lawrence, KS 66045

ERIC Facility-Acquisitions
4350 East-West Hwy.
Suite 1100
Bethesda, MD 20814-4475

Dr. Beatrice J. Farr
Army Research Institute
PERI-IC
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Marshall J. Farr
Consultant
Cognitive & Instructional
Sciences
2520 North Vernon Street
Arlington, VA 22207

Dr. P-A. Federico
Code 51
NPRDC
San Diego, CA 92152-6800

Dr. Paul Feltovich
Southern Illinois University
School of Medicine
Medical Education Department
P.O. Box 3926
Springfield, IL 62708

Mr. Wallace Feurzeig
Educational Technology
Bolt Beranek & Newman
10 Moulton St.
Cambridge, MA 02238

Dr. Gerhard Fischer
Liebiggasse 5/3
A 1010 Vienna
AUSTRIA

Dr. Gerhard Fischer
University of Colorado
Dept of Computer Science
Boulder, CO 80309

Dr. Linda Flower
Carnegie-Mellon University
Department of English
Pittsburgh, PA 15213

Dr. Barbara A. Fox
University of Colorado
Department of Linguistics
Boulder, CO 80309

Dr. Carl H. Frederiksen
Dept. of Educational Psych.
McGill University
3700 McTavish Street
Montreal, Quebec
CANADA H3A 1Y2

Dr. John R. Frederiksen
BBN Laboratories
10 Moulton Street
Cambridge, MA 02238

Dr. Norman Frederiksen
Educational Testing Service
(05-R)
Princeton, NJ 08541

Dr. Michael Friendly
Psychology Department
York University
Toronto ONT
CANADA M3J 1P3

Dr. Robert M. Gagne
1456 Mitchell Avenue
Tallahassee, FL 32303

Dr. Dedre Gentner
University of Illinois
Department of Psychology
603 E. Daniel St.
Champaign, IL 61820

Psychology Department
George Mason University
4400 University Drive
Fairfax, VA 22030

Dr. Robert D. Gibbons
IL State Psychiatric Inst.
Rm 529W
1601 W. Taylor Street
Chicago, IL 60612

Dr. C. Lee Giles
AFOSR/NE, Bldg. 410
Bolling AFB
Washington, DC 20332

Dr. Herbert Ginsburg
Box 184
Teachers College
Columbia University
525 West 121st Street
New York, NY 10027

Mr. Lee Gladwin
Route 3, Box 225
Fay Street
Winchester, VA 22601

Dr. Robert Glaser
LRDC
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15260

Dr. Arthur M. Glenberg
University of Wisconsin
W. J. Brogden Psych. Bldg.
1202 W. Johnson Street
Madison, WI 53706

Dr. Marvin D. Glock
101 Homestead Terrace
Ithaca, NY 14856

Dr. Sam Glucksberg
Department of Psychology
Princeton University
Princeton, NJ 08540

Dr. Susan R. Goldman
Dept. of Education
University of California
Santa Barbara, CA 93106

Dr. Sherrie Gott
AFHRL/MOMJ
Brooks AFB, TX 78235-5601

Dr. T. Govindaraj
GA Institute of Technology
School of Industrial
and Systems Engineering
Atlanta, GA 30332-0205

Dr. Wayne Gray
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Bert Green
Johns Hopkins University
Department of Psychology
Charles & 34th Street
Baltimore, MD 21218



Dr. James G. Greeno
School of Education
Stanford University
Room 311
Stanford, CA 94305

Prof. Edward Haertel
School of Education
Stanford University
Stanford, CA 94305

Dr. Henry M. Halff
Halff Resources, Inc.
4918 33rd Road, North
Arlington, VA 22207

Dr. Ronald K. Hambleton
University of Massachusetts
Laboratory of Psychometric
and Evaluative Research
Hills South, Room 152
Amherst, MA 01003

Dr. Ray Hannapel
Scientific and Engineering
Personnel and Education
National Science Foundation
Washington, DC 20550

Dr. John R. Hayes
Carnegie-Mellon University
Department of Psychology
Schenley Park
Pittsburgh, PA 15213

Dr. Barbara Hayes-Roth
Knowledge Systems Lab
Stanford University
701 Welch Road
Palo Alto, CA 94304

Dr. Melissa Holland
Army Research Institute
for the Behavioral and
Social Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Keith Holyoak
Department of Psychology
University of California
Los Angeles, CA 90024

Ms. Julia S. Hough
Lawrence Erlbaum Associates
110 W. Harvey Street
Philadelphia, PA 19144

Dr. Lloyd Humphreys
University of Illinois
Department of Psychology
603 East Daniel Street
Champaign, IL 61820

Dr. Ed Hutchins
Intelligent Systems Group
Inst. for Cognitive Science
UCSD
La Jolla, CA 92093

Dr. Huynh Huynh
College of Education
Univ. of South Carolina
Columbia, SC 29208

Dr. Alice M. Isen
Department of Psychology
University of Maryland
Catonsville, MD 21228

Dr. Janet Jackson
Rijksuniversiteit Groningen
Biologisch Centrum, Vleugel D
Kerklaan 30, 9751 NN Haren
The NETHERLANDS

Dr. Robert Jannarone
Elec. and Computer Eng. Dept.
University of South Carolina
Columbia, SC 29208

Dr. Claude Janvier
Universite' du Quebec
a Montreal
P.O. Box 8888, succ: A"
Montreal, Quebec H3C 3P8
CANADA

Dr. Robin Jeffries
Hewlett-Packard Laboratories
3L
P.O. Box 10490
Palo Alto, CA 94303-0971

Dr. Douglas H. Jones
Thatcher Jones Associates
P.O. Box 6640
10 Trafalgar Court
Lawrenceville, NJ 08648

CAPT Tom Jones
ONR Code 121D
800 N. Quincy Street
Arlington, VA 22217-5000

Dr. Marcel Just
Carnegie-Mellon University
Department of Psychology
Schenley Park
Pittsburgh, PA 15213

Dr. Ruth Kanfer
University of Minnesota
Department of Psychology
Elliott Hall
75 E. River Road
Minneapolis, MN 55455

Dr. Milton S. Katz
European Science Coordination
Office
U.S. Army Research Institute
Box 65
FPO New York 09510-1500

Dr. Frank Keil
Department of Psychology
228 Uris Hall
Cornell University
Ithaca, NY 14850

Dr. Wendy Kellogg
IBM T. J. Watson Research Ctr.
P.O. Box 704
Yorktown Heights, NY 10598

Dr. Dennis Kibler
University of California
Department of Information
and Computer Science
Irvine, CA 92717

Dr. David Kieras
Tech.Communication Program
TIDAL Bldg.
2360 Bonisteel Blvd.
University of Michigan
Ann Arbor, MI 48109-2108

Dr. Kenneth Kotovsky
Community College of
Allegheny Co.
808 Ridge Avenue
Pittsburgh, PA 15212

Dr. Pat Langley
University of California
Department of Information
and Computer Science
Irvine, CA 92717

Dr. Jill Larkin
Carnegie-Mellon University
Department of Psychology
Pittsburgh, PA 15213

Dr. Jean Lave
Institute for Research
on Learning
3333 Coyote Hill Road
Palo Alto, CA 92304

Dr. Robert W. Lawler
Matthews 118
Purdue University
West Lafayette, IN 47907

Dr. Alan M. Lesgold
Learning R&D Center
University of Pittsburgh
Pittsburgh, PA 15260

Dr. John Levine
Learning R&D Center
University of Pittsburgh
Pittsburgh, PA 15260

Dr. Michael Levine
Educational Psychology
210 Education Bldg.
University of Illinois
Champaign, IL 61801

Dr. Clayton Lewis
University of Colorado
Dept of Computer Science
Campus Box 430
Boulder, CO 80309

Matt Lewis
Department of Psychology
Carnegie-Mellon University
Pittsburgh, PA 15213

Library
Naval Training Systems Ctr
Orlando, FL 32813

Library
Naval War College
Newport, RI 02940

Science and Technology Div.
Library of Congress
Washington, DC 20540

Dr. Marcia C. Linn
Graduate School of Education
EMST
Tolman Hall
University of California
Berkeley, CA 94720

Dr. Robert L. Linn
Campus Box 249
University of Colorado
Boulder, CO 80309-0249

Dr. Richard E. Mayer
Department of Psychology
University of California
Santa Barbara, CA 93106

Dr. James R. McBride
The Psychological Corporation
1250 Sixth Avenue
San Diego, CA 92101

Dr. Joseph C. McLachlan
Code 52
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. James McMichael
Technical Director
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. Barbara Means
SRI International
333 Ravenswood Avenue
Menlo Park, CA 94025

Dr. Douglas L. Medin
Department of Psychology
University of Illinois
603 E. Daniel Street
Champaign, IL 61820

Dr. George A. Miller
Dept. of Psychology
Green Hall
Princeton University
Princeton, NJ 08540

Dr. Andrew R. Molnar
Applications of Advanced
Technology
Science and Engr. Education
National Science Foundation
Washington, DC 20550

Dr. William Montague
NPRDC Code 13
San Diego, CA 92152-6800

Dr. Randy Mumaw
Training Research Division
HumRRO
1100 S. Washington
Alexandria, VA 22314

Dr. Allen Munro
Behavioral Technology Labs
USC
1845 S. Elena Ave., 4th Floor
Redondo Beach, CA 90277

Dr. Richard E. Nisbett
University of Michigan
Institute for Social Research
Room 5261
Ann Arbor, MI 48109

Dr. Donald A. Norman
C-015
Inst. for Cognitive Science
University of California
La Jolla, CA 92093

Deputy Technical Director
NPRDC Code 01A
San Diego, CA 92152-6800

Director
Training Laboratory
NPRDC (Code 05)
San Diego, CA 92152-6800

Director
Manpower and Personnel Lab
NPRDC (Code 06)
San Diego, CA 92152-6800

Director
Human Factors & Organizational
Systems Lab
NPRDC (Code 07)
San Diego, CA 92152-6800

Library, NPRDC
Code P201L
San Diego, CA 92152-6800

Technical Director
Navy Personnel R&D Center
San Diego, CA 92152-6800

Commanding Officer,
Naval Research Laboratory
Code 2627
Washington, DC 20390

Dr. Harold F. O'Neil, Jr.
School of Education - WPH 801
Department of Educational
Psychology & Technology
USC
Los Angeles, CA 90089-0031

Dr. Stellan Ohlsson
Learning R & D Center
University of Pittsburgh
Pittsburgh, PA 15260

Office of Naval Research
Code 1142
800 N. Quincy St.
Arlington, VA 22217-5000

Office of Naval Research,
Code 1142BI
800 N. Quincy Street
Arlington, VA 22217-5000

Office of Naval Research
Code 1142CS
800 N. Quincy Street
Arlington, VA 22217-5000
(6 Copies)

Office of Naval Research
Code 1142PS
800 N. Quincy Street
Arlington, VA 22217-5000

Office of Naval Research
Code 125
800 N. Quincy Street
Arlington, VA 22217-5000

Psychologist
Office of Naval Research
Branch Office, London
Box 39
FPO New York, NY 09510

Special Assistant for Marine
Corps Matters,
ONR Code 00MC
800 N. Quincy St.
Arlington, VA 22217-5000

Dr. Judith Orasanu
Basic Research Office
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Military Assistant for Training
and Personnel Technology,
OUSD (R & E)
Room 3D129, The Pentagon
Washington, DC 20301-3080

Dr. Ray S. Perez
ARI (PERI-II)
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. David N. Perkins
Project Zero
Harvard
Graduate School of Education
7 Appian Way
Cambridge, MA 02138

Dr. Tjeerd Plomp
Twente University of Technology
Department of Education
P.O. Box 217
7500 AE ENSCHEDE
THE NETHERLANDS

Dr. Martha Polson
Department of Psychology
University of Colorado
Boulder, CO 80309-0345

Dr. Harry E. Pople
University of Pittsburgh
Decision Systems Laboratory
1360 Scaife Hall
Pittsburgh, PA 15261

Dr. Joseph Psotka
ATTN: PERI-IC
Army Research Institute
5001 Eisenhower Ave.
Alexandria, VA 22333-5600

Dr. Lynne Reder
Department of Psychology
Carnegie-Mellon University
Schenley Park
Pittsburgh, PA 15213

Dr. Steve Reder
Northwest Regional
Educational Laboratory
400 Lindsay Bldg.
710 S.W. Second Ave.
Portland, OR 97204

Dr. James A. Reggia
University of Maryland
School of Medicine
Department of Neurology
22 South Greene Street
Baltimore, MD 21201

Dr. J. Wesley Regian
AFHRL/IDI
Brooks AFB, TX 78235

Dr. Fred Reif
Physics Department
University of California
Berkeley, CA 94720

Dr. Lauren Resnick
Learning R & D Center
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15213

Dr. Gilbert Ricard
Mail Stop K02-14
Grumman Aircraft Systems
Bethpage, NY 11787

Dr. Linda G. Roberts
Science, Education, and
Transportation Program
Office of Technology Assessment
Congress of the United States
Washington, DC 20510

Dr. William B. Rouse
Search Technology, Inc.
4725 Peachtree Corners Circle
Suite 200
Norcross, GA 30092

Dr. Fumiko Samejima
Department of Psychology
University of Tennessee
310B Austin Peay Bldg.
Knoxville, TN 37916-0900

Dr. Robert Sasmor
HQDA DAMA-ARL
Pentagon, Room 3E516
Washington, DC 20310-0631

Dr. Walter Schneider
Learning R&D Center
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15260

Dr. Alan H. Schoenfeld
University of California
Department of Education
Berkeley, CA 94720

Dr. Janet W. Schofield
816 LRDC Building
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15260

Dr. Judith W. Segal
OERI
555 New Jersey Ave., NW
Washington, DC 20208

Dr. Colleen M. Seifert
Inst. for Cognitive Science
Mail Code C-015
University of California
La Jolla, CA 92093

Dr. Lee S. Shulman
School of Education
507 Ceras
Stanford University
Stanford, CA 94305-3084

Dr. Randall Shumaker
Naval Research Laboratory
Code 5510
4555 Overlook Avenue, S.W.
Washington, DC 20375-5000

Dr. Robert S. Siegler
Carnegie-Mellon University
Department of Psychology
Schenley Park
Pittsburgh, PA 15213

Dr. Edward Silver
LRDC
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15260

Robert L. Simpson, Jr.
DARPA/ISTO
1400 Wilson Blvd.
Arlington, VA 22209-2308

Dr. Zita M. Simutis
Chief
Technologies for Skill
Acquisition and Retention
ARI
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Derek Sleeman
Computing Science Department
King's College
Old Aberdeen AB9 2UB
Scotland
UNITED KINGDOM

Dr. Richard E. Snow
School of Education
Stanford University
Stanford, CA 94305

Dr. Elliot Soloway
Yale University
Computer Science Department
P.O. Box 2158
New Haven, CT 06520

Dr. Richard C. Sorensen
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. Paul Speckman
University of Missouri
Department of Statistics
Columbia, MO 65201

Dr. Robert J. Sternberg
Department of Psychology
Yale University
Box 11A, Yale Station
New Haven, CT 06520

Dr. Thomas Sticht
Applied Behavioral and
Cognitive Sciences, Inc.
P.O. Box 6640
San Diego, CA 92106

Mr. Brad Sympson
Navy Personnel R&D Center
Code-62
San Diego, CA 92152-6800

Dr. John Tangney
AFOSR/NL, Bldg. 410
Bolling AFB, DC 20332-6448

Dr. Kikumi Tatsuoka
CERL
252 Engineering Research
Laboratory
103 S. Mathews Avenue
Urbana, IL 61801

Dr. M. Martin Taylor
DCIEM
Box 2000
Downsview, Ontario
CANADA M3M 3B9

Dr. Perry W. Thorndke
FMC Corporation
Central Engineering Labs
1205 Coleman Avenue, Box 580
Santa Clara, CA 95052

Dr. Martin A. Tolcott
3001 Veazey Terr., N.W.
Apt. 1617
Washington, DC 20008

Dr. Douglas Towne
Behavioral Technology Labs
USC
1845 S. Elena Ave.
Redondo Beach, CA 90277

Dr. Robert Tsutakawa
University of Missouri
Department of Statistics
222 Math. Sciences Bldg.
Columbia, MO 65211

Dr. Zita E. Tyer
Department of Psychology
George Mason University
4400 University Drive
Fairfax, VA 22030

Headquarters,
U. S. Marine Corps
Code MPI-20
Washington, DC 20380

Dr. Kurt Van Lehn
Department of Psychology
Carnegie Mellon University
Schenley Park
Pittsburgh, PA 15213

Dr. Jerry Vogt
Navy Personnel R&D Center
Code 51
San Diego, CA 92152-6800

Dr. Ming-Mei Wang
Lindquist Center for
Measurement
University of Iowa
Iowa City, IA 52242

Dr. Beth Warren
BBN Laboratories, Inc.
10 Moulton Street
Cambridge, MA 02238

Dr. Kent E. Williams
Inst. for Simulation
and Training
University of Central Fla
P.O. Box 25000
Orlando, FL 32816-0544

Dr. Hilda Wing
NRC MH-176
2101 Constitution Ave.
Washington, DC 20418

Ms. Marilyn Wingersky
Educational Testing Service
Princeton, NJ 08541

Dr. Robert A. Wisher
U.S. Army Institute for the
Behavioral & Social Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333-5600

Dr. Martin F. Wiskoff
Defense Manpower Data Center
550 Camino El Estero, Suite 200
Monterey, CA 93943-3231

Mr. John H. Wolfe
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. George Wong
Biostatistics Laboratory
Memorial Sloan-Kettering
Cancer Center
1275 York Avenue
New York, NY 10021

Dr. Wallace Wulfeck, III
Navy Personnel R&D Center
Code 51
San Diego, CA 92152-6800

Dr. Masoud Yazdani
Dept. of Computer Science
University of Exeter
Prince of Wales Road
Exeter EX44PT
ENGLAND

Dr. Joseph L. Young
National Science Foundation
Room 320
1800 G Street, N.W.
Washington, DC 20550